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accepting the same position, but differ in methods of reaching it: the conclusion of Descartes being the starting point with Reid (p. 106).

The fourth article consists of emendations of the French translation of Kant's *Prolegomena* published by Hachette, Paris, 1891.

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Species and Varieties: Their Origin by Mutation. Lectures delivered at the University of California. By HUGO DE VRIES. Edited by D. T. MACDOUGAL. Chicago, The Open Court Publishing Co., 1905.—pp. xviii, 847.

When the author's 'Mutationstheorie' appeared (Vol. I, 1901, Vol. II, 1903), it was characterized as the most important contribution which had been made to the theory of evolution since the time of Darwin. Following that appearance, it has been shown that a number of independent lines of investigation converge to support and confirm the hypothesis advanced therein.

The 'Mutationstheorie' presented the complete detailed evidence, obtained from trustworthy historical records and from experimental researches carried on for twenty years, for this new theory of the origin of species. The present volume repeats some of these descriptions, but the results of new experiments have been added and a wider choice of material has been made from recent current literature on the subject. It is, however, the more important phases that are here emphasized.

At the beginning, it is important to note that, in the author's own opinion, the results of his work are in almost full accord with the principles laid down by Darwin. In one point, however, they differ. If Darwin's theory is a theory of selection, it is not necessarily a theory of descent, and that of de Vries is this. All evolutionary science is now based on the general idea of descent with modification, but this is quite independent of the modus in single instances of the change of one species into another.

The present work consists of twenty-eight lectures arranged in six groups. The first lecture is an introduction dealing with 'Theories of Evolution' and 'Methods of Investigation.' Natural selection is only a sieve, and is not a force of nature or a direct cause of improvement. It presupposes such a change. Darwin recognized two methods of change, the one, mutations, the other, variations or 'fluctuations.' Wallace and the Neo-Lamarckians reject the first, but in de Vries's opinion "species are *not known* to originate in any other way" than by the first. Fluctuations are inadequate even to make a single step along the great lines of evolution. They occur only around a mean, obeying Quetelet's law of probability, and have never been observed to produce anything quite new.

But this is not the only objection to a theory of descent based on them. There is also the very serious one of incompatibility between such a theory of slow and nearly invisible yet accumulating changes and the results as to the age of the earth as given by the geologists and the astronomers.

The second division of lectures (II–IV) deals with 'Elementary Species in Nature.' Here and elsewhere it seems that de Vries distinguishes two ways in which species may originate: (*a*) by mutation, (*b*) by hybridization, according to the Mendelian law. The second presupposes, however, the constant unit-characters arising by the first method alone, and constituting elementary species. The test for a species of any kind consists in establishing the constancy of its unit-characters in pedigree-cultures.

Elementary species are not produced by man; nature alone does this by mutation. Their characters are not destroyed by intercrossing, but remain pure, and may be isolated whenever it is desired. But either as crossed or uncrossed, natural selection, by way of climate and soil and vegetable and animal enemies, operates as a sieve on them, so that some characters are kept, others lost.

In lectures V–XV, the author presents the evidence to show that 'varieties' are produced either by the loss of some marked peculiarity, or by latent characters becoming active, or by the acquisition of others that are already present in allied species. Only the elementary species form the *progressive* links of the chain from the lower to the higher forms; varieties are only local and lateral.

'No organism exhibits all of its qualities at any one time'; these may be dormant and awaiting a period of activity either regular or irregular. This means that unit-characters, having once been acquired, may become latent, and may reappear, and that this process is of universal occurrence throughout the whole vegetable and animal kingdom. The author accordingly finds that there are three aspects in the evolution at least of plants, viz., progression, retrogression, and 'degression.' In the first, there results an ever-increasing divergency; in the second, *permanent latency*, the diversity is increased; in the third, temporary latency, 'systematic atavism,' characters seemingly lost reappear. The test for the progression-constituting nature of mutations is a twofold one. First, they distinguish themselves by falling outside the curve on which the variations of any character in reference to a standard unit fall. This curve of probability is found by taking as the ordinates the coefficients of the binomial $(a + b)^n$ and arranging these ordinates at equal distances.

The second test is by hybridization according to the Mendelian formula. Starting with a contrasting pair of characters, one, say, a mutation, it is found that in the second generation and afterward these differentiating characters reappear in their purity and according to the mathematical law that each separates in each of these generations in *one fourth* of the progeny and thereafter remains true. A new character having appeared, it can in this way be shown to be a permanent acquisition.

Lectures XVI–XXIV. Although the author tested many species, only one, the evening primrose, *Œnothera*, gave positive, mutating, results. He finds that the various mutations obtained from this species take place with a great degree of regularity. Very simple rules of *general validity*, he assumes, govern the whole phenomenon:

I. 'New elementary species appear suddenly, without intermediate steps.' This is contradictory to the usual conception of very slow changes. 'No series of generations, no selection, no struggle for existence are needed for this.'

II. 'New forms spring laterally from the main stem.' There is neither a slow nor a sudden change of all the individuals; the vast majority remain unchanged. A species like *Œnothera Lamarckiana* will not die out from mutating. This is in contrast with the current conception that the slow conversion of one species into another affects all the individuals in the same direction and degree, and that the birth of the new species involves the death of the old one. Again, 'mutation' gives *several new species* from one parental form; according to the other view, only one was given.

III. No elementary species attain their full constancy at once. Constancy is a quality of its own, the result of neither selection nor improvement.

IV. 'The same new species are produced in a large number of individuals.' Obviously there must be some common cause which has lain dormant during many successive generations.

V. Mutations are not extreme fluctuations. In the latter there is a heaping up of slight deviations around a mean, and an occurrence of continuous lines of increasing deviations, linking the extremes with this group. Nothing of the kind is found in the case of mutations.

There is no mean for them to be grouped around; the extreme only is to be seen, and it is wholly unconnected with the original type. Fluctuations are subject to reversions, mutations are not.

VI. The mutations take place in nearly all directions. 'Some may be favorable, others detrimental, many of them without significance either way.' 'How these differences originate has nothing to do with the theory of natural selection nor with the struggle for life.' But if the useful directions are given a number of times, a cumulation and a progression are possible, which give the effect of an *apparent predisposition.*

These facts necessitate a distinction in 'natural selection.' Lectures XXV–XXVIII. There is selection of two kinds, between species and between varieties. In the first there is a reduction in the number of *species.* Some thrive and multiply, others not. New mutations appear, and the sifting-selection occurs. This explains the manifold highly complicated structure which strikes the beginner as adaptation. The second, intra-species selection, crowns the first. It brings isolated forms to the highest possible degree of usefulness, adapts strains to local conditions, produces local races. It produces lateral branches, but no main stems of pedigree, no lasting improvement.

One question of great importance remains to be discussed: Is mutability a temporary and periodic or a permanent condition? If the latter, then it has no beginning and is not due to external circumstances. If the former, there was a beginning due to an external cause; although the amount and direction may be 'assumed to be due to internal causes.' Which of these agrees best with the facts of species not at present mutable? By the second view this would mean for these the 'loss of the capacity for further development.' By the first, this capacity could be regained and all lines of the genealogical tree might progress. Experience must decide between the two main theories. Now, however, it shows a previous state of mutability in a large number of polymorphous genera; while, on the other hand, many facts plead in favor of the constancy of species.

The mutation theory conciliates the two. Reducing the changeability of the species to distinct and *probably short* periods, it allows for the constancy so emphasized by the systematist, and for the descent through modification of the evolutionist.

It grants the present constancy of the vast majority of living forms, and only claims the exceptional occurrence of definite changes, while the indications are that these periods of stability and mutability alternate more or less regularly with one another.

At certain periods, then, new species arise in considerable numbers, and each of them in large numbers of individuals. The multiple origin has the effect of strengthening the new types. A large part of the mutations, being either injurious or useless, disappear.

This failure may be made a principle. If, in order to secure one good novelty, nature must produce many bad ones at the same time, the possibility of improvements coming by pure *chance* must be granted at once, and all hypotheses concerning the direct causes of adaptation at once become superfluous.

Accordingly, in this new view of phylogenetic development, aside from its very great technical importance for biology and for all evolutionary doctrine, the reviewer finds much of great philosophical interest, especially as regards the questions of origin and of purpose.

In the discussion of practically all questions of origin, there are two typical views which are taken. The one is advanced by the man who emphasizes the necessity of keeping the law of identity intact. Accordingly, for him all change or origin in which something new apparently comes into existence consists at bottom only of changes in the configuration (motion) of a system made up of some kind of *elements*, which in that way should retain their identity with themselves. If he be a physicist and use differential equations, then these elements are conceived of as mass-points. This type is found to be characterized by the conviction that such a procedure is more *logical*, and by its insistence on certain principles as self-evident and therefore as necessarily true. However, to hold to be true is not to be true.

The other type of thinker is able to use the same equations without finding it necessary to conceive or image their meaning in any such terms. Physical change for him is not in every case a diminutive cosmical or molar phenomenon, a change of place; but there are as well changes of state, of qualities, to which the equations are applied, and which are frankly admitted to present something quite new and not deducible from *elements* of any kind. The conditions in the presence of which the new appears, *i. e.*, the critical point, can be empirically established; or, within certain limits, the degree of change or appearance of something new can be found by experiment to be a function of an independent variable. Thus there is established a purely *empirical law of determination*. Before, however, such experimentation is made, it is quite impossible to predict either the critical point or the new qualities which shall appear there; and afterward it is equally impossible to deduce these from any elements that might be chosen. There is here no logical determination or necessity, but recognition is frankly made of a *de novo* origin, of discontinuity, of a '*chance*' appearance. To the law of identity and to 'elements' no attention is paid.

Into this last scheme, there fit the appearance of the new qualities resulting, *e. g.*, in the synthesis of every chemical compound, and, at the *critical* point, under definite conditions of temperature and pressure, etc., of every physical state.

In the origin of species by mutation, the reviewer finds what seems to be another case of the same kind. Experiment shows that organisms *of the same descent* under the *same* conditions give diverse mutations, and this after a long period of constancy. The factors causing these are accordingly internal. Even if, then, the external conditions for inducing mutations were known, and could be used, it would be impossible to say beforehand what the character of even one mutation would be. But the fact of diversity precludes seemingly the establishing of any empirical law of determination even after one or more mutations have occurred.

There seems to be, therefore, an absolute irregularity here. For we have either many characters coming from one cause (what de Vries calls a 'pangene') in the germ; or else there are as many such causes as there are unit-characters appearing. This last does not do away with the irregularity, but puts it back only one step further; as also is the case, with a difference in number only, if it is claimed that the cause has been long latent. At some point of time, epigenesis, chance, perhaps irregularity are to be admitted, or else 'there is nothing new under the sun.'

But there is another set of experimental facts brought out by the work of Driesch, Boveri, Conklin, and Wilson on germinal *prelocalization* in the egg which bear on this question. These investigators have been able to show that the eggs of a number of species contain *localized areas* of *protoplasm* which have a causal connection with the formation of definite parts of the embryo; also that this grouping of stuffs in the egg is gradual; *i. e.*, that at first even it contains few if any of these specific stuffs; that the chromosomes of the nucleus are the bearers of the hereditary characteristics and probably cause this grouping. The nucleus appears to contain an original preformation of elements which correspond each for each to the unit-characters of the coming organism. These cause the cytoplasm to develop epigenetically. Accordingly, for a new unit-character to appear, must not a new cause in the chromosome arise *de novo*, and is it not therefore very difficult to escape the acceptance of chance or absolute irregularity here? Why should one not accept this, except that it is illogical? But *why* should nature not have this prerogative?

The space is lacking to allow of many more comments. It is evident that the new theory of mutations must be recognized in all discussions of questions as to origin and development. For instance, if the empirical view of consciousness be taken, why should it not be quite possible that this has appeared in the phylogenetic development of certain species as a mutation? And what becomes of those arguments for design which have been based on adaptation by slow accumulative changes? Evidently the work of de Vries may well prove to be an epoch-making contribution to the advance of knowledge. It makes the study of evolution in part experimental, modifies the current views as to origin, selection, and adaptation, and finds a place for non-heredity and discontinuity, for chance and irregularity.

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